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Review and use of the Algerian renewable energy for sustainable development

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ABSTRACT

Given Algerian's abundant solar, wind resources, biomass, geothermal, etc. represent a potential market for renewable energy technologies. This article presents a review and the use of renewable energy situation in Algeria. The analysis of the present renewable energy situation and future objective are also discussed.

Contents

1. Introduction

Ever since its establishment in 1976, the Arab League Education, Culture and Scientific Organisation (ALECSO) has given a great emphasis to the importance of Arab cooperation in the field of renewable energy, bearing in mind that the world is increasing its demand, year after year, on limited sources of non-renewable energy. At the same time renewable energy policy has become an essential ingredient of social and economic development plans in the Arab as well as at the world level [1].

According to the special report on emission scenarios issued by the Intergovernmental Panel on Climate Change (IPCC) under the auspices of the UN, the global average surface temperature has increased over 20th century by $0.6 \pm 0.2\,^{\circ}C$. Prehistoric global

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warming led to a complete transformation of the Earth's surface, with the disappearance of ice sheets, and massive changes in vegetation cover, regional extinctions and a sea-level rise of about 120 m.

In fact using models of the carbon cycle, that is, of how carbon is moved around between the atmosphere, the biosphere, the soil and the oceans, the IPCC estimated that by 2100, atmospheric carbon dioxide concentrations would range in total anywhere from 490 to 1260 ppm such concentrations are 75–350% higher than the pre-industrial estimate of 280 ppm in 1750. Carbon dioxide concentrations in 2005 are already about 378 ppm, or 35% above the pre-industrial value [2].

In 2007, Algeria's natural gas is the largest source of electricity production as it accounts for almost 98% of total electricity with remaining 1% came from small hydroelectric plants [3]. The growth in population has a direct impact on energy requirements. Fig. 1 shows the growth of number of consumers and the electric energy consumption in some selected years.

With respect to Algeria, there were 4,897,000 electricity consumers in the year 2002 which reached to 6,041,000 in the year 2007. The growth of number of consumers from year to year looks linear. While the energy growth reached 37,060 GWh in the year 2007 from 27,400 GWh in 2002. The above significant increases can be attributed to rapid growth in residential, commercial, and industrial sectors.

With this growth in electric demand the Algerian government has realized the importance of renewable energy. It has been realized that the renewable energy projects could be used as tools for the management of reserves and sustainable development of desert communities.

There are generally areas where a diesel or gas-powered generator presents a problem of fuel transportation and may potentially harm the environment.

The government has initiated programs that aim at increasing the use of renewable energy technologies in Algeria, therefore providing green power to isolated villages and combating global climate change, especially greenhouse gas emissions [4].

The share of renewable energy sources in Algeria primary energy supply is relatively low compared with European countries, though the trends of development are positive. One of the main strategic priorities of New Energy ALgeria (NEAL) which is Algeria's renewable energy agency (government, SONELGAZ and Sonatrach), is striving to achieve a share of renewable energy sources in primary energy supply of 10–12% by 2010 [5].

NEAL beside government support has solicited several sources of funding to support these projects including World Bank, AIE and the European bank of investment. The following sections present topography of Algeria and a review of renewable energy potential and projects undertaken in Algeria.

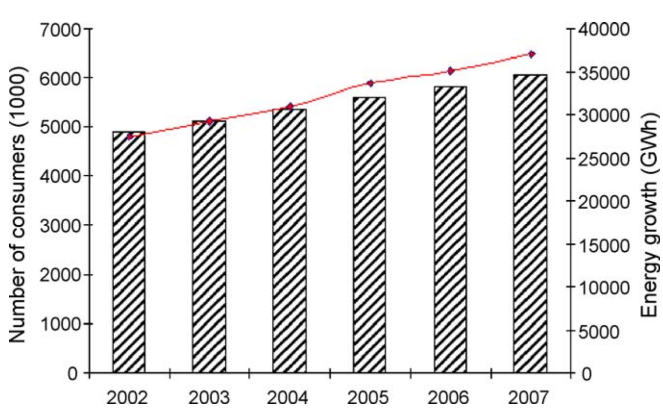

Fig. 1. Year-wise growth in number of consumers and energy growth.

Table 1
Annual rates of electricity production worldwide using renewable energy resources (*Source*: Ref. [3]).

Rank	Energy source	Power (MW)	Energy ($\times 10^9$ kWh)
01	Hydraulic	769,000	3902.1
02	Geothermal	8,600	59.34
03	Wind	25,000	43
04	Solar	2,086	5.9
05	Photovoltaic	2,443	2.7
Total		807,129	3203.03

2. Power generation with renewable energy resources worldwide

About 3203 billion kWh of electricity is generated annually worldwide. As seen in Table 1. With renewable energy resources that include water, wind, solar, biogas and geothermal heat comprising about 20% of the Earth's total electricity consumption (16015.15 billion kWh) [6].

Hydroelectric power makes up the greatest share or 96% of the renewable sources. The next largest share goes to geothermal heat sources producing 8600 MW of power and more than 59 billion kWh of electricity. Wind power generators with a total power of 25,000 MW and 43 billion kWh of electricity generation ranks third. The last sources on this list include solar energy with a power generation in the scale of 5.9 billion kWh and photovoltaic generators producing 2.7 billion kWh of electricity.

Electric power generated with renewable energy resources will continue to reach a level of 3500 billion kWh by 2010 based on the current rates of increase. If the increase in electricity generation is to amount to 2% every year some 17,500 billion kWh would be needed for the year 2010. In other words the share of renewable energy would be 20%. Currently a figure of €12 billion per year is considered for the construction of power generators using renewable energy resources. The figure should increase to €30 billion by the year 2010 [6].

3. Topography and energy data of Algeria

Algeria's geographic location has several advantages for extensive use of most of the renewable energy sources (RES) (wind, geothermal, biomass, solar, etc.). Algeria is situated in the centre of North Africa between the 35° and 38° of latitude north and 8° and 12° longitude east, has an area of 2,381,741 km^2 and a population of 32.5 millions of inhabitants. The Sahara occupies the 80% of the area [7]. It lies, in the north, on the coast of the Mediterranean Sea. The length of the coastline is 2400 km. In the west Algeria borders with Morocco, Mauritania and occidental Sahara, in the southwest with Mali, in the east with Tunisia and Libya, and in the southeast with Niger. The climate is transitional between maritime (north) and semi-arid to arid (middle and south). The mean annual precipitation varies from 500 mm (in the north) to 150 mm (in the south). The average annual temperature is about 12 °C [8,9].

4. Wind energy

Wind energy can be feasible where the average wind velocity is higher than 5–6 m/s. In Algeria, the best wind energy potential is in the southwestern region where the wind velocity is higher than 6 m/s [4] as seen in Fig. 2.

Youcef Ettoumi et al. [10] performed wind power potential assessment for five locations in Algeria using nine types of small and medium wind turbines from five manufacturers. They

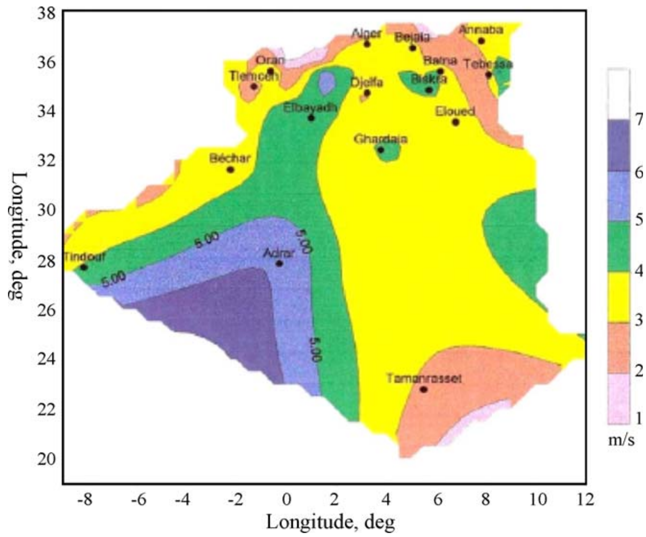

Fig. 2. Wind map evaluation in Algeria [4].

concluded that most of these turbines are found to produce about 1000–10,000 MWh of electricity per year at 60 m of altitude and can easily satisfy the electricity need in irrigation and its household applications in rustic and arid regions. Himri et al. [11] utilized wind speed data over a period of almost 10 years for three stations, namely Adrar, Timimoun and Tindouf to assess the wind power potential at these sites. They estimated that wind farms of 30 MW installed capacity can be established at Adrar, Timimoun and Tindouf, if constructed, these wind farms can produce 98,832, 78,138 and 56,040 MWh of electricity annually. In another study, Himri et al. [12] presented the wind characteristic at three locations in Algeria. They revealed that the energy could be harnessed for almost 64% the time using wind machines with cut-in speed of 3 m/s or more. Himri et al. [7] conducted a study to perform an economical feasibility of an existing grid connected diesel power plant supplying energy to a remotely located by adding wind turbine/s in the existing power system in order to reduce the diesel consumption and environmental pollution, using HOMER simulation model. They found that the wind diesel hybrid system becomes feasible at a wind speed of 5.48 m/s or more and a fuel price of 0.162$/L or more. Himri et al. [13] determined the wind power potential in Tindouf region, Algeria using a computer package program called the Wind Atlas Analysis and Application Program (WAsP).

The Algerian government has been promoting the use of wind energy by means of a series of laws and official programmes [14]. NEAL has solicited several sources of funding and supporting its projects. On the one hand the projected objectives is included within a solicited actions supported and financed by World Bank, AIE and the European bank of investment. Whereas on the other, it also receives funds from the Algerian government.

Practical applications of wind energy, however, are still limited due to the high costs and the need for advances in technology. It is now important in educating the public as well as introducing special energy legislation to increase the usage of this clean form of energy whether in private or public sectors and show the importance of energy efficiency and conservation.

5. Geothermal

Algeria is divided into two regions by the South Atlas Fault in the north and the Saharan Platform in the south (Fig. 3). There are more than 200 hot springs which one-third's temperatures are superior to 45 °C and where the temperature reaching 98 °C at Hammam Meskoutine (northeastern region) [15] as seen in Fig. 4. The highest temperature registered is 118 °C in the southeastern part of the country [16]. Few studies have been undertaken to asses the geothermal potential although it exploration was started in

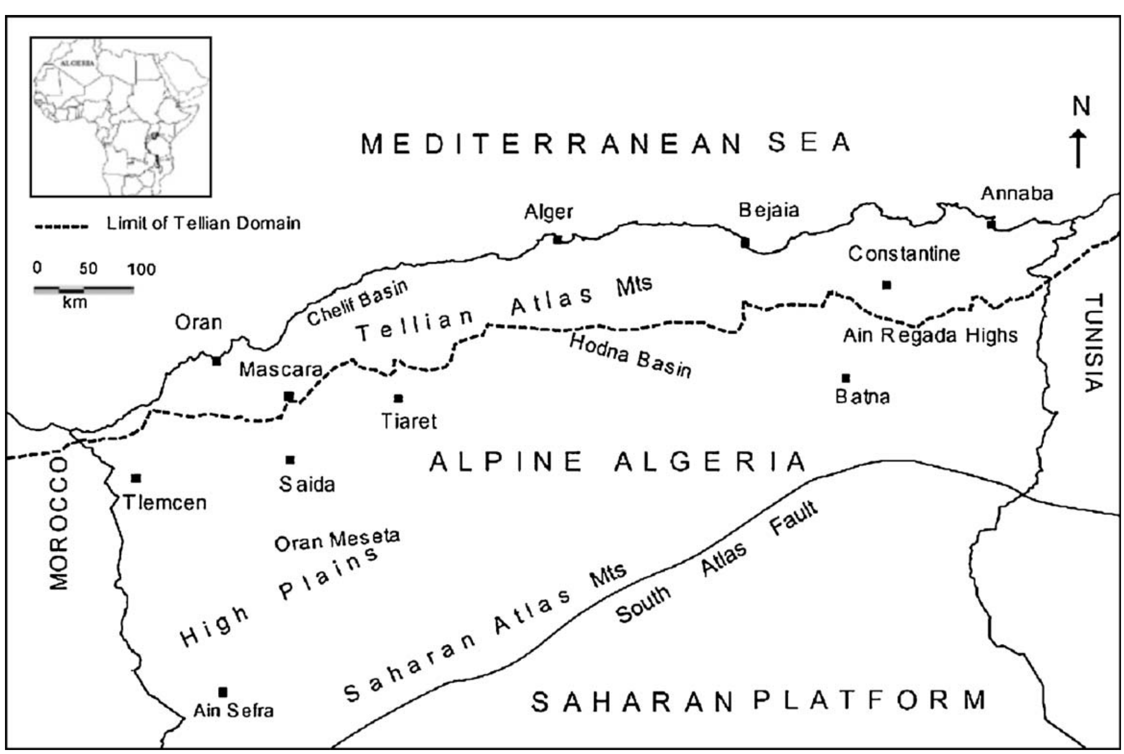

Fig. 3. Geological units of Northern Algeria [13].

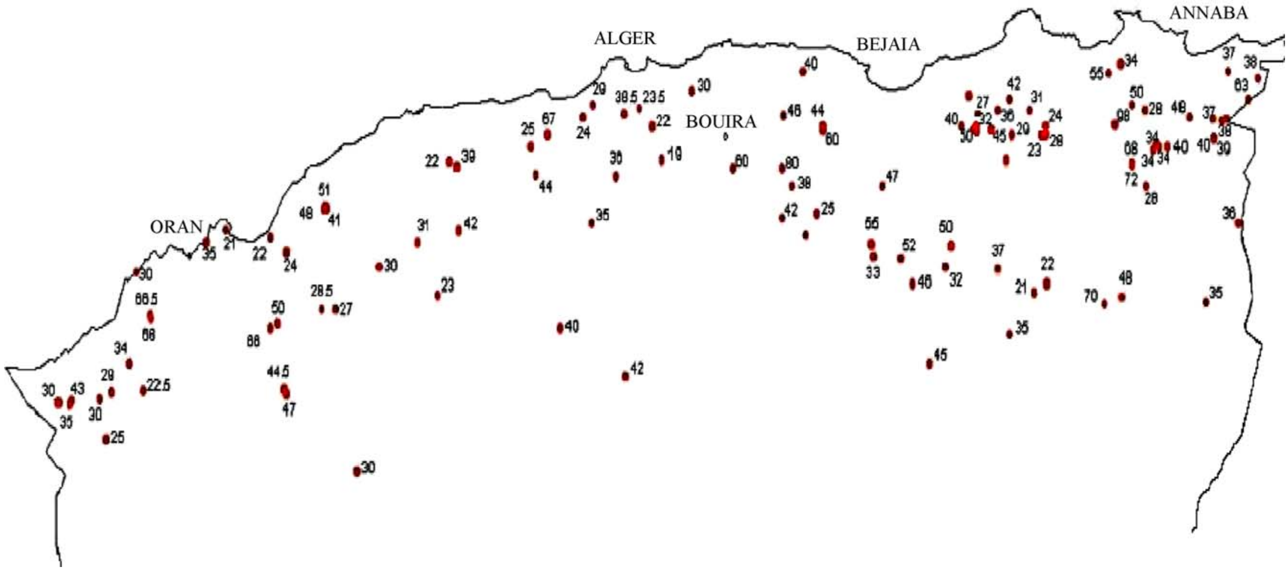

Fig. 4. Geothermic chart of Algeria.

1967 [17]. Fekraoui [18] reviewed the geothermal resources in Algeria and their possible use. The main chemical characteristics of the sampled thermal springs and the results of the application of geothermometers are presented by Lahlou Mimi et al. [19].

Kedaid [17] described database on the low-temperature geothermal resources of Algeria and gave a description of hot water resources, and thematic maps. In 2005, the geothermic capacity installed is 152.3 MWt of which 2.3 MWt is for greenhouse heating, 0.1 MWt for space heating, and the rest (149.9 MWt) for bathing and for balneology uses [20].

Actually, the existing geothermal resources such as thermal springs and wells are using only for space heating like greenhouse heating at Hammam Maskhoutine, Touggourt and Ghardaia A residential heating system, fed by 69 °C geothermal water, is also planned for Hammam Righa. There are non-electric applications of geothermal heat in spite of that a project was envisaged for installation of a small power plant in the Bouhadjar zone, east Algeria [18].

6. Biomass

The biomass potentially offers great promises with bearing of 3.7 millions of TEP coming from forests and 1.33 million of TEP per year coming from agricultural and urban wastes; however this potential is not enhanced and consumed yet [6]. Biomass can be burnt directly or it can be converted into solid, gaseous and liquid fuels using conversion technologies such as fermentation to produce alcohols, bacterial digestion to produce biogas and gasification to produce a natural gas substitute. Industrial, agricultural livestock and forest residues can be used as a biomass energy source [21]. Biomass technology was introduced to Algeria in 1950s, when l'Institut National d'Agronomie (INA) d'El Harrach (Algiers) used a biomass plant which produced combustible gas (biogas) via organic waste [22]. Tebib [23] evaluated the potential of vegetable residues (olive pits) in the northern part of Algeria as shown in Fig. 5, he proposed that plant of 6 MW installed capacity can be established at Bejaia if constructed, this plant can consume about 70,000 t of olive pits annually to produce approximately 45 GWh/year. Bennouna and Kehal [24] demonstrate the role of sullage purification stations and the potential that it can be exploited for the production of biogas in Algeria. Kaidi and Touzi [25] suggested producing ethylic alcohol from the waste of dates rich in fermentescible sugars (60%). The used process consists in a classic alcoholic fermentation followed by a double distillation. Tou et al. [26] proposed biomethane production from animal dungs. They found that this organic matter, at the local level, will allow to produce energy with lesser cost for domestics application and fertilizers with high-fertilizing value as amendments for the agricultural lands. SONELGAZ's biomass power project is at the feasibility study stage in Oued Smar site, at an installed capacity of 2 MW that can reach a peak of 6 MW from the discharge of this site (urban waste and sewage) [27].

In Algeria, biomass can be used to meet a variety of energy needs, including generating electricity, heating homes and providing process heat for industrial facilities.

7. Solar energy

Solar energy is the most abundant natural resource in Algeria. It becomes imperative for Algeria to exploit this important resource. The overall installed photovoltaic (PV) power is about 1.2 MW [6]. The insolation time over the quasi-totality of the national territory exceeds 2000 h annually and may reach 3900 h (Sahara). The daily

Fig. 5. Example of vegetable residues (olive pits) in the region of Kabylie, Bejaia [22].

Table 2
Solar potential in Algeria: table of statistics of the sunshine hours per zone (*Source*: MEM Ministère de l'énergie et des mines).

Region	Coastal	High plateau	Sahara
Surface (%)	04	10	86
Average duration of sunniness per annum (h)	2650	3000	3500
Average energy received (kWh/(m^2 annum))	1700	1900	2650

obtained energy on a horizontal surface of 1 m^2 is 5 kWh over the major part of the national territory, or about 1700 kWh/(m^2 year) for the north and 2650 KWh/(m^2 year) for the south of the country [27] (see Table 2).

The solar applications, by implanting photovoltaic power plants, are an extension of already existing diesel power stations in isolated areas and are limited to electrification, pumping, telecommunication, public lighting and small refrigeration systems.

7.1. Solar water pumping

Water pumping for irrigation and drinking for rural communities and villages in Algeria represents an important area of stand-alone PV systems, indeed in these areas, there is a great solar energy potential and a hydraulic potential is not very deep underground.

The activities in photovoltaic power systems programs namely research, education and market penetration in Algeria are reported by Maafi [28]. Hamidat [29] computed the electrical and hydraulic performance of a surface centrifugal pump using three PV array sizes (1050, 1400 and 1750 W peaks) and several total dynamic heads. He found that the cost of the water per cubic metre for low-total dynamic head (less than 14 m) thus it will be able to contribute in supplying water in the remote Sahara regions.

In another study Hamidat and Benyoucef [30] suggested two models of photovoltaic pumping sizing, the first used a centrifugal pump and the second used a positive displacement pump. They found that the results obtained are very satisfactory. Benatiallah et al. [31] studied the performance of photovoltaic solar system in Algeria in order to see the behaviour and adaptation in conditions of sites as well as the climatic and social condition effect on the working and the profitability for a long time. Benghanem et al. [32] presented a design of a universal data acquisition system for the performance analysis of photovoltaic water pumps system PVWPS in Algeria. Bouaouadja et al. [33] studied the effects of the sandblasting duration on the efficiencies of solar panels they concluded that the solar panels' efficiencies decreases during sandstorms and some of these decreases are permanent when the protective glass sheets are damaged by erosion.

Hadj Arab et al. [34] introduced the loss-of-load probability (LLP) sizing method into water pumping applications operating in different sites in Algeria. Bouzidi et al. [35] analysed the performance of a photovoltaic pumping system installed in an isolated site at Ghardaia, south of Algeria to evaluate the economic interest of the PV system which will have to satisfy a mean daily volume of 60 m^3 throughout the year as compared to the diesel genset (DG), by using the method of the life cycle cost (LCC). Mellit et al. [36] performed the use of adaptive wavelet-network architecture in finding a suitable forecasting model for predicting the daily total solar radiation over the period extending from 1981 to 2001, for a meteorological station in Algeria. The authors showed that the model predicts daily total solar-radiation values with a good accuracy of approximately 97% and the mean absolute percentage error is not more than 6%.

Maafi and Adane [37] used the first-order two-state Markov chains for modelling daily sunshine duration and global solar-radiation data, recorded in Reading United Kingdom, Kuwait-City (Kuwait) and various locations in Algeria (i.e., Algiers, Batna, Oran and Setif) during periods of 8–21 years. In addition a detailed investigation has been occurred on the properties involved by the limiting distribution of first-order two-state Markov chains, are useful for sizing stand-alone photovoltaic systems in Algiers and for analyzing their performances. Mellit et al. [38] presented an adaptive artificial neural network (ANN) for modeling and simulation of a stand-alone photovoltaic (SAPV) system operating under variable climatic conditions. The study demonstrated that the comparison between simulated and experimental signals of the SAPV gave good results. The correlation coefficient obtained varies from 90% to 96% for each estimated signals, which is considered satisfactory. Also a comparison between multilayer perceptron (MLP), radial basis function (RBF) network and the proposed Levenberg-Marquardt algorithm and an infinite impulse response (LM–IIR) is presented. Sadok et al. [39] conducted the performances of a photovoltaic system and analysed the most representative parameters of its functioning. Mellit et al. [40] presented an adaptive neuro-fuzzy inference system (ANFIS) model for estimating sequences of mean monthly clearness index and total solar-radiation data collected from 60 locations in Algeria. They reached that the root mean square error (RMSE) between measured and estimated values varies between 0.0215 and 0.0235 and the mean absolute percentage error (MAPE) is less than 2.2%.

7.2. Solar distillation

The integration of renewable resources such as solar in desalination and water purification seems to be attractive and alternative way for supplying small communities in remote areas with water, this is because these technologies have low operating and maintenance costs, the solar distillation could be the most favourable way for this use. Boukar and Harmim [41] presented performance evaluation of one-sided vertical solar still tested under desert climatic conditions of Algeria, in summer and autumn seasons 2003. The study showed that still yield varies from 0.275 to 1.31 l/m^2 d for a corresponding energy varying from 8.42 to 14.71 MJ and daily overall efficiency ranging from 7.85% to 21.19%. Boukar and Harmin [42] investigated the effect of desert climatic conditions on the performance of a simple basin solar still and a similar one coupled to a flat plate solar collector. Tests were conducted at the solar station of Adrar, an Algeria Saharan site. They resolved that the daily still productivity in summer period varied from 4.01 to 4.34 l/(m^2 d) for simple basin solar still and from 8.02 to 8.07 l/(m^2 d) for the coupled one. Bouchekima et al. [43] presented the results of experiments carried out with a capillary film distiller installed in the south of Algeria, in a village near Touggourt where the temperature of the groundwater was about 65 °C at the source, for groundwater distillation using solar energy and the capillary. It was found that the efficiency of this distiller increased with increasing the temperature of the brackish water at the inlet and also with increasing the intensity of the solar radiation and it depended besides on the heat loss and fabric used. Bouchekima [44] conducted the evaluation of a solar distillation system, showing the benefits of this system concerning water productivity and exploitation of solar energy. Sadi and Kehal [45] reviewed the retrospectives and potential use of saline water desalination in Algeria. They related that an experimental study of a small solar desalination plant using reverse osmosis was installed in the small village of Hassi-Khebbi situated in a desert zone 1400 km southwest of Algeria. This installation produced nearly 1000 l/h of fresh water from underground brackish water.

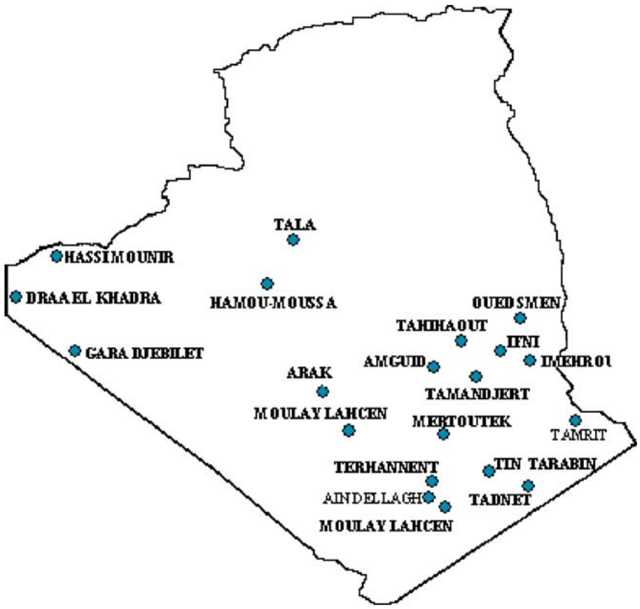

Fig. 6. Installation of photovoltaic in 20 villages of the desert of Algeria.

Recently, the photovoltaic panels have been utilized for various applications in Algeria. Some of these applications include

- Electrification with solar power of 20 villages spread out among the four wilayas of the south: Tamanrasset, Tindouf, Illizi and Adrar. The solar energy produced by these systems is above 1.5 GWh as shown in Fig. 6.
- A solar hybrid (photovoltaic/diesel) power station of 13 kW in power station of 13 KW in Illizi, beaconing of 2300 km of roads.
- Supplying electricity for more than 100 telecommunications stations (650 kW).
- Electrification of more than 300 houses (550 kW), the total cost of this project was estimated at €115,000.
- 10 kW photovoltaic power station connected to the national grid.
- One oil station fed with solar energy (7 kW).

Ongoing projects:

- NEAL Company: 150 MW hybrid power station (solar/gas), with 34 MW solar.
- Development of the market of solar energy water heater carried out by APRUE (Promotion of the Rational Use of Energy) to equip 5500 houses and 16,000 m^2 in the tertiary sector.
- Rural electrification program: provide photovoltaic electricity to 16 villages with a total of 800 houses (0.5 MW).

This developing strategy, by SONELGAZ, has been elaborated to promote the dissemination of renewable energies on sites where they are profitable compared to classical energies and to guide scientific research efforts in order to allow generalisation of renewable energy via mass production. The aims to be achieved consist of the contribution to a conservative policy for hydrocarbons both by increasing the renewable energy share within the national energy balance and by improving the living conditions of isolated communities. In the absence of any reference, this first operation led by SONELGAZ would allow on one hand to supply isolated area with electricity and on the other hand to collect information about

- Equipment behaviour in Saharan environment.
- Matching the systems with the electricity supply.
- Maintenance organisation and management.
- Technical-economic system optimisation.

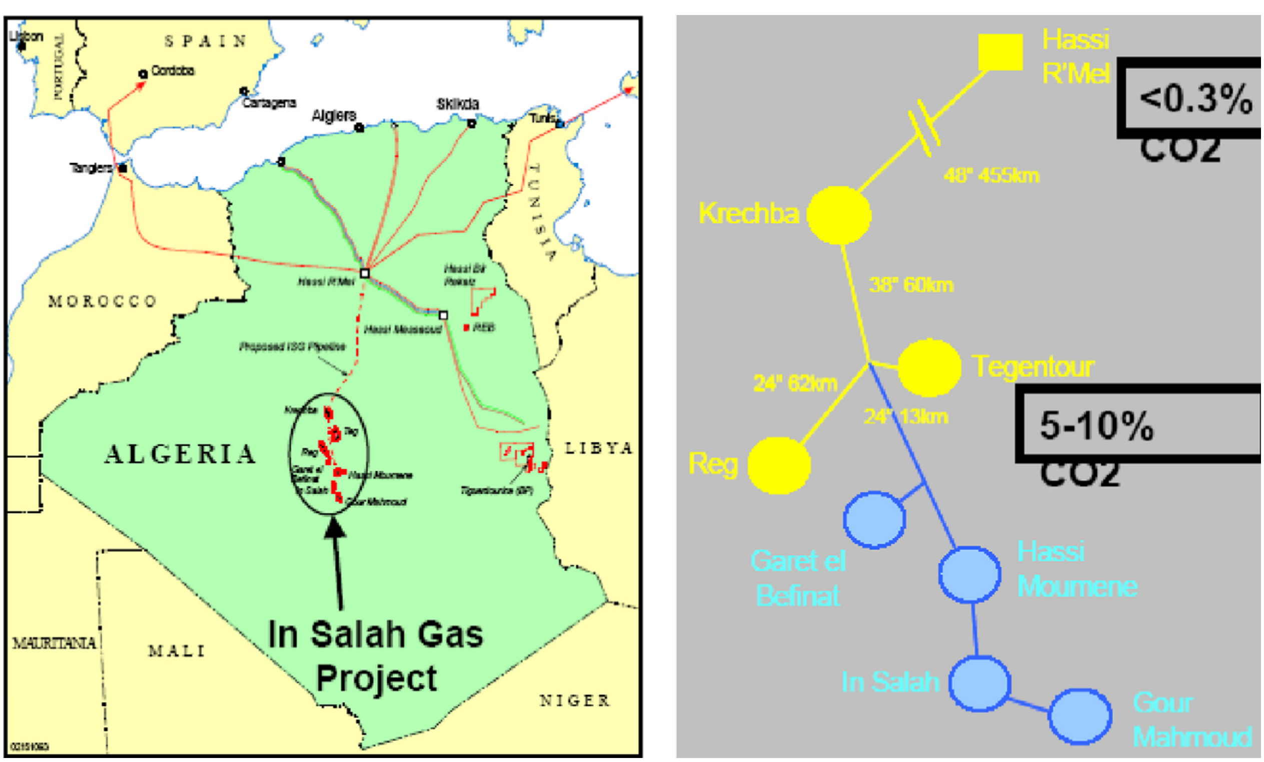

Fig. 7. The eight gas fields layout showing CO_2 injectors and producers in In Salaha, Algeria.

Table 3
List of present and near future CO_2 storage [46].

Year	Location	CO_2 injection rate (million tonnes/year)	Project type	Operator
1996	Sleipner, Norway	1	Storage	Statoil
2000	Weyburn, Canada	1.2	EOR	EnCana
2004	In Salah, Algeria	1.3	Storage	BP
2004	K12B	0.2	Storage	Gaz de France
2006	Snøhvit	0.7	Storage	Statoil
2009	Gorgon, Australia	3.3	Storage	Chevron

8. CO_2 storage

In Salah Gas Project in Algeria comprising eight gas fields in the central Saharan region [46], see Fig. 7.

It is the world's largest CO_2 capture and storage project which was constructed in 2004 by a joint venture between SONATRACH "Algeria's National Energy Company" (35%), "British Petroleum" BP (33%) and The Norwegian company Statoil (32%) to avoid venting gas into the atmosphere, capture carbon dioxide and inject it into a brine formation a mile below the surface. Rough the IEA International Energy Agency [47] estimates of how much CO_2 could be stored in the various geological options are 15 Giga tonnes in unminable coal seams, 920 Giga tonnes in depleted oil and gas fields and 400–10,000 Giga tonnes in deep saline aquifers. Table 3 lists the large-scale CO_2 injection projects worldwide. Fig. 8 shows a picture of CO_2 storage project in Algeria. The world's largest CO_2 capture plant at the In Salah gas development project in Algeria. There is no CO_2 tax in Algeria and storage of CO_2 is being done for environmental considerations only. Starting in 2004, approximately 1.2 million tonnes per year CO_2 has been removed, compressed and in this case injected at a depth of 1800 m into an aquifer section at a remote corner of the Krechba gas field [48]. The increasing number of storage projects worldwide provides a basis for improved strategies for the mitigation and management of risk associated with deep geological storage.

The geological setting at the Krechba gas field appears to be highly suitable for long-term geological storage of CO_2. This CO_2 project is considered among an excellent analogue for other countries: China, Europe, and North America and offers an ideal opportunity to gain important additional information on the permanence and safety of CO_2 geologic storage.

Since the inception of the In Salah Gas Project, world interest in CO_2 sequestration and carbon free power and fuels systems has increased considerably. Like many other firms, the shareholder companies of In Salah Gas are all pursuing research and development into the many areas where application of green technologies can yield lasting benefits. Learning from the In Salah Gas Project is an important part of this effort [49]

9. Barriers to renewable energy development

The full potential and advantages of renewables are currently hindered in Algeria due to the existence of many barriers like the institutional barriers and the price of fossil fuels which are often subsidized the "externalities" associated with the use of such resources, additional health and environmental costs, are not considered:

- Weak inter-sectoral coordination and communication which not only tends to slow down the promotion of such projects, but also leads to the duplication of efforts and weakens human capital build up.
- Slow process in implementing Decrees of Application that takes time and prevents implementation of much needed measures for the promotion of such projects.
- *Human capital.* Continuity of personnel is essential and also rotation of staff prevents a long-term accumulation of experience and the process becomes too dependent on individual involvement, or lack thereof.
- *Lack of knowledge networks.* Capacity building seminars on an issue of interest to different stakeholders may only benefit some due to lack of information dissemination.

10. Conclusion

Algeria has introduced laws and regulations aimed at promoting renewable energy (RE) to introduce an effort for restraining energy demand and improve environmental conditions either in private or public sector. So it is essential in education to learn and make public conscious of energy efficiency and conservation. The implementation of various projects allows Algeria to play an important role not only in the Maghreb countries but also in the Europe. Within its policy of climate and environment protection,

Fig. 8. Current In Salah of CO_2 storage.

the Algerian government fully supports the objective of the Concentrating Solar Power (CSP), Global Market Initiative (GMI) to build a number of power plants with a total capacity of 5000 MW of CSP worldwide and, secondly, to construct two power system interconnection cables (Algeria–Spain and Algeria–Italy) with an import/export capacity of 1200 MW. Meanwhile, both Algeria and the private sector are aware of Europe's commitment to renewable energy sources, in particular the European Union's aim to have 12% of renewable energy by 2010.

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References

[1] Alnaser WE, Al Kalak A, Al Azraq MAT. The efforts of the Arab League Education, Culture and Scientific Organization (ALECSO) in the field of renewable energy. Renewable Energy 1995;6(56):649–57.
[2] Barrie Pittock A. Climate change turning up the heat. Published by CSIRO Publishing; 2005. p. 316 [ISBN: 064306931].
[3] SONELGAZ. Dalil. Direction de la Comptabilité et du Contrôle de Gestion. Electricity and Gas National Enterprise, Alger-Algerie; 2007.
[4] Himri Y. Optimisation de certains paramètres d'un Aérogénérateur situe dans le Sud Ouest de l'Algérie. Mémoire de magister, Université de Béchar Algérie; Mai 2005.
[5] Himri Y, Boudghene Stambouli A, Draoui B, Himri S. Review of wind energy use in Algeria. Renewable and Sustainable Energy Reviews; accepted February 2008.
[6] Boudghene Stambouli A. Overview and perspectives of the Algerian renewable energy. In: Programme environment 2007 conference; 2007.
[7] Himri Y, Boudghene Stambouli A, Draoui B, Himri S. Techno-economical study of hybrid power system for a remote village in Algeria. Energy 2008;33:1128–36.
[8] Askri H, Belmecheri B, Boudjema A, Boumendjel K, Daoudi M, Drid M, et al. Geology of Algeria. Internal report Schlumberger-WEC, SONATRACH; 1995. p. 93. Link: http://www.mem-algeria.org:80/fr/hydrocarbures/w1_0.pdf.
[9] Sicard C. Les énergies solaire et éolienne en Algérie. tome III – OCS 81 DZ 232–Juillet 1981.
[10] Youcef Ettoumi F, Adane Abd, Lassaad Benzaoui M, Bouzergui N. Comparative simulation of wind park design and setting in Algeria. Renewable Energy 2008;33:2333–8.
[11] Himri Y, Rehman S, Draoui B, Himri S. Wind power potential assessment for three locations in Algeria. Renewable and Sustainable Energy Reviews 2008;12:2495–504.
[12] Himri Y, Draoui B, Himri S. Wind characteristics of Algeria. In: The 2008 NSTI, nanotechnology conference and trade show.
[13] Himri Y, Boudghene Stambouli A, Draoui B, Himri S. An investigation on wind power potential in Tindouf region Algeria. In: Proceedings of world academy of science, engineering and technology, vol. 32, WASET 2008 congress [ISSN: 1307-6884].
[14] Journal officiel de la république Algérienne démocratique et populaire. Conventions et accords internationaux Lois et Décrets, Arrêtes, Décisions, Avis, Communications et Annonces Correspondant au 28 juillet 1999 relative à la maîtrise de l'énergie.
[15] Askri H, Belmecheri B, Boudjema A, Boumendjel K, Daoudi M, Drid M, et al. Geology of Algeria. Internal report Schlumberger-WEC, Sonatrach; 1991. 93 pp.
[16] Bellache O, Hellel M, Abdelmalik EH, Chenak A. Geothermal heating of greenhouses in Southern Algeria. In: Proceedings of the world geothermal congress of Italy, vol. 3; 1995. p. 2285–90.
[17] Kedaid FZ. Database on the geothermal resources of Algeria. Geothermics 2007;36:265–75.
[18] Fekraoui A. Geothermal resources in Algeria and their possible use. Geothermics 1988;(17):515–9.
[19] Lahlou Mimi A, Ben Dhia H, Ouri S, Lahrach A, Ben Abidate L, Bouchareb - Haouchim FZ. Application of chemical geothermometers to thermal springs of the Maghreb North Africa. Geothermics 1998;27(2):211–33.
[20] Lund JW, Freeston DH, Boyd TL. World wide direct uses of geothermal energy 2005. In: Proceedings of world geothermal congress of Antalya, Turkey; 2005.
[21] Mustafa Omer A. Renewable energy resources for electricity generation in Sudan. Renewable and Sustainable Energy Reviews 2007;11:1481–97.
[22] Ministère de l'Aménagement du territoire de l'Environnement Direction Générale de l'Environnement. Projet national ALG/98/G31 Elaboration de la stratégie et du plan d'action national des changements climatiques; Mars 2001.
[23] Tebib A. La Production Electrique à partir de la Biomasse Oléicole: le Potentiel Algérien. MEDénergie Maghreb 2004. p. 46–51.
[24] Bennouna M, Kehal S. Production de Méthane à partir des Boues des Stations d'épuration des Eaux Usées Potentiel existant en Algérie. Numéro Spécial Biomasse Production et Valorisation Alger; juin 20–21, 2001. p. 18–22.
[25] Kaidi F, Touzi A. Production de Bioalcool à Partir des Déchets de Dattes. Rev Energ Ren Production et Valorisation – Biomasse 2001;75–8.
[26] Tou I, Igoud S, Touzi A. Production de Biométhane à Partir des Déjections Animales. Numéro Spécial Biomasse Production et Valorisation Alger; juin 20–21, 2001. p. 60–3.
[27] Hattabi S. Algeria in pole position. Published in Energy and Mines sector. Periodic review of the Energy and Mines sector no. 2; April 2004. p. 105. Link: http://www.memalgeria.org:80/larevue/the_mag/energie_2-eng.pdf.
[28] Maafi A. A survey on photovoltaic activities in Algeria. Renewable Energy 2000;20:9–17.
[29] Hamidat A. Simulation of the performance and cost calculations of the surface pump. Renewable Energy 1999;18:383–92.
[30] Hamidat A, Benyoucef B. Mathematic models of photovoltaic motor-pump systems. Renewable Energy 2008;33:933–42.
[31] Benatiallah A, Mostefaou R, Bradja K. Performance of photovoltaic solar system in Algeria. Desalination 2007;209:39–42.
[32] Benghanem M, Hadj Arab A, Mukadam K. Data acquisition system for photovoltaic water pumps. Renewable Energy 1999;17:385–96.
[33] Bouaouadja N, Bouzid S, Hamidouche M, Bousbaa C, Madjoubi M. Effects of sandblasting on the efficiencies of solar panels applied. Energy 2000;65:99–105.
[34] Hadj Arab A, Chenlo F, Benghanem M. Loss-of-load probability of photovoltaic water pumping systems. Solar Energy 2004;76:713–23.
[35] Bouzidi B, Haddadi M, Belmokhtar O. Assessment of a photovoltaic pumping system in the areas of the Algerian Sahara. Renewable and Sustainable Energy Reviews; accepted January 2008.
[36] Mellit A, Benghanem M, Kalogirou SA. An adaptive wavelet-network model for forecasting daily total solar-radiation. Applied Energy 2006;83:705–22.
[37] Maafi A, Adane A. Analysis of the performances of the first order two state Marvov model using solar radiation properties. Renewable Energy 1998;13(2):175–93.
[38] Mellit A, Benghanemb M, Kalogirou SA. Modeling and simulation of a stand-alone photovoltaic system using an adaptive artificial neural network: proposition for a new sizing procedure. Renewable Energy 2007;32:285–313.
[39] Sadok M, Mehdaoui A, Hamek T. Monitoring and performances evaluation of Sapvs in south of Algeria. Renewable Energy 1998;I5:590–3.
[40] Mellit A, Kalogirou SA, Shaari S, Salhi H, Hadj Arabe A. Methodology for predicting sequences of mean monthly clearness index and daily solar radiation data in remote areas: application for sizing a stand-alone PV system. Renewable Energy 2008;33:1570–90.
[41] Boukar M, Harmim A. Performance evaluation of a one-sided vertical solar still tested in the desert of Algeria. Desalination 2005;183:113–26.
[42] Boukar M, Harmim A. Effect of climatic conditions on the performance of a simple basin solar still: a comparative study. Desalination 2001;137:15–22.
[43] Bouchekima B, Gros B, Ouahes R, Diboun M. Performance study of the capillary film solar distiller. Desalination 1998;116:185–92.
[44] Bouchekima B. A solar desalination plant for domestic water needs in arid areas of South Algeria. Desalination 2002;153:65–9.
[45] Sadi A, Kehal S. Retrospectives and potential use of saline water desalination in Algeria. Desalination 2002;152:51–6.
[46] Riddiford F, Wright A, Bishop C, Espie T, Tourqu A. Monitoring geological storage, the In Salah gas CO_2 storage project; 2004. Paper available at: http://uregina.ca/ghgt7/PDF/papers/nonpeer/529.pdf.
[47] International Energy Agency (IEA). Prospects for CO_2 capture and storage; 2004 [ISBN: 92-64-10881-5].
[48] Steenveldt R, Berger B, Torp TA. CO_2 capture and storage closing the knowing–doing gap chemical engineering. Research and Design 2006;84(A9):739–63.
[49] Driscoll J, Benyoub S, Riddiford F. CO_2 sequestration in the In Salah Gas Project. In: Programme environment 2007 conference; 2007.